XIII. ELECTRICAL SYSTEMS: ELECTRICAL AND LIGHTING

INTRODUCTION

In 1914, when the Utah State Capitol's cornerstone was laid, electricity was used in the workplace mainly as a source of energy for lighting, motor operated equipment, and resistance heating elements. The scope of the electrical specifications was " a complete installation of power and light wiring from the termini of the Utah Light and Traction Company feed wires, to Boiler House entrance to tunnel, with 4 fibre conduits laid in concrete through tunnel and basement floor to transformer room and connected herewith."[65] Although the National Electrical Code had been in publication for 19 years, there is no indication that it was used as a standard for the construction of the electrical systems within the Utah State Capitol. Even if it had been used it would have little relevance to modern electrical installations. Advancements in the development of incandescent lighting that provided longer lasting lamps were just being completed. Utah Power and Light Company, founded in 1912, was celebrating its second anniversary. It would be another 25 years before the first fluorescent lamp would be developed. The typical workspace would not have an appliance, other than a possible desk lamp, that would plug into a wall receptacle. Long distance communication via the telephone was still in its infancy and the telephone was not a common instrument in the workplace. RCA would not begin manufacturing vacuum tubes until 1920 and the personal computer would not be found on the average desk until the 1990's. The devices that were used for distribution of electricity gave priority to function over safety.

While electrical energy is still used as an energy source for lighting and motor operated equipment it is also used as an energy source for the electronic communications devices that have infiltrated the workplace. The use of computers and telephones for information exchange has made the workplace completely dependent upon the use of electrical energy. In addition, workers have a higher expectation of comfort in the workplace that has increased the demands that are placed upon the electrical system. Expectations for increased lighting levels and more comfortable lighting have increased the demands on the electrical systems. Air conditioning, also dependent upon electrical energy, was uncommon when the Capitol was constructed but is now found in every workplace. Electronic security devices such as cameras and door controls were not even conceived let alone invented when the Capitol was constructed. Life Safety systems such as smoke detecting fire alarm systems and smoke control systems were not available at the time of construction.

This lack of systems at the time of construction resulted in the construction of a minimal electrical system that forms a very weak foundation for the modern electrical system. The building design did not include conduits, chases, accessible spaces, and rooms that could be used to house electronic equipment and the associated wiring. Remodels of portions of the building have made provisions for the installation of electrical equipment and wiring but these have all been patchwork provisions that have resulted in an unorganized and wholly inadequate electrical system. Although we may be as blind to future innovations that require the use of electrical energy as our predecessors, we must make every effort to assure that the renovations of the electrical system include provisions for today's systems as well as the systems that will be installed in the foreseeable and distant future. To accomplish this task the restoration must include construction of electrical systems that provide for a strong foundation to build upon. A strong foundation will include an electrical power system that is adequate in terms of capacity, reliability, and flexibility. In addition, distribution systems for power and communications wiring must be flexible, conveniently accessible, and organized.

The standards and criteria are developed to address the project goals of:

Life Safety

Function -Efficiency /Effectiveness

Historic /Architectural Integrity

1. LIFE SAFETY

a. STANDARD: Promote all aspects of life safety.

1) Objective: Use UL listed electrical and lighting equipment.

2) Objective: Install per National Electrical Code and local requirements.

3) Objective: Facilitate emergency operations and evacuation of the building.

b. STANDARD: Maximize reliability of life safety electrical systems

1) Objective: Unsure that life safety systems are functioning properly when needed.

2) Objective: Reduce maintenance cost associated with life safety systems.

2. FUNCTION - EFFICIENCY / EFFECTIVENESS

a. STANDARD: Use efficient equipment that is effective in application

1) Objective: Provide lighting fixtures and control systems that meet or surpass the applicable energy codes.

2) Objective: Provide program control systems to minimize energy usage while providing required lighting levels and quality of lighting, both for the interior and for the exterior.

3) Objective: Use efficient lamps and ballasts that are suitable for the application, including improved office lighting, required lighting for television cameras, and increased site illumination for safety and security.

4) Objective: Provide an electrical service that is suitable for today's technological offices and tasks and provides a solid foundation for future installation.

5) Objective: Provide an organized electrical branch wiring system that is flexible to meet the needs of a constantly changing environment.

6) Objective: Install lighting and other equipment in a manner that promotes safe maintenance, reduces maintenance costs, and minimizes the number of different lamps used.

3. HISTORIC / ARCHITECTURAL INTEGRITY

a. STANDARD: Provide lighting and electrical systems that respect the Historic and Architectural Integrity of the building.

1) Objective: Provide lighting fixtures in public spaces that are state-of- the-art renovations of existing, original equipment.

2) Objective: Provide an electrical service, distribution and branch circuit wiring systemthat is not intrusive to the historic spaces.

3) Objective: Increase the lighting levels to provide required circulation and task lighting in a manner that appears original or in the theme of the period nature of the building.

4. SPECIFIC STANDARDS AND CRITERIA USED IN THE ANALYSIS OF ELECTRICAL AND LIGHTING

a. National Fire Protection Association No. 70-1999, <u>The National Electrical Code</u> (NFPA-70)

b. International Conference of Building Officials, <u>Uniform Building Code</u> (UBC-1997)

c. Illumination Engineering Society of North America, (IESNA) RP-1-99, <u>Recommended Practice for Office Lighting</u>

d. Illumination Engineering Society of North America, (IESNA)<u>, Lighting Handbook</u>, 9th Edition

e. American Society fo Heating, Refrigeration, and Air Conditioning Engineers/ Illumination Engineering Society of North America (IESNA), Joint Standard, ASHRAE/IESNA 90.1-89 , <u>Energy Code</u>

f. Illumination Engineering Society of North America (IESNA), RP5-99 <u>Recommended Practice for Daylighting</u>

g. Illuminating Engineering Society of North America, (IESNA) RP-20-98 <u>Recommended Practice for Parking Facility Lighting</u>

h. Illuminating Engineering Society of North America, (IESNA) RP-33-99 <u>Recommended Practice Lighting Exterior Environments</u>

i. Illuminating Engineering Society of North America, (IESNA) HANDBOOK, 9th Ed. <u>Recommended Practice for Television Lighting</u>

j. Underwriter's Laboratories <u>Standard UL 1570 - Standard for Fluorescent Lighting Fixtures</u>

1. Capitol Grounds Electrical Distribution System

Near the northwest corner of the capitol grounds there is an overhead power line where the connection to the Utah Power distribution system is made. The Utah Power distribution lines operate at 12,470 volts, 3 phase which is a common distribution voltage. Power lines that operate at 12,470 volts are typically referred to as medium voltage lines. These lines are taken underground from a power pole to a metering cabinet located near to the pole. The metering cabinet contains equipment that is used by Utah Power to meter electric power and energy consumption for all buildings that are located on the Capitol Grounds. These buildings include the Archives Building, Boiler Plant, Data Processing Center, State Office Building, Greenhouse, Cafeteria, Plaza, and State Capitol Building. All equipment, including transformers and medium voltage switchgear, that is located downstream of the metering cabinet is owned by the State of Utah. The metering cabinet and all of the medium voltage cables and equipment downstream were installed in 1986 as part of an electrical distribution systems upgrade.

From the metering cabinet the medium voltage lines are installed in an underground duct. The medium voltage lines consist of one 350 kcmil (thousand circular mils) copper conductor per phase and a #4/0 copper grounding conductor. The phase conductor insulation is ethylene-propylene rubber (EPR), 15 kilovolt (kv). The grounding conductor insulation is type THW which is constructed from flame retardant, heat and moisture resistant thermoplastic. The duct in which these cables are installed is a 5 inch non-metallic duct that is concrete encased. Using this arrangement the medium voltage conductors have a rating of 375 amps.

The medium voltage conductors terminate in a lineup of metalclad switchgear that is located within a small building between the State Office Building and the Data Processing Center. The metalclad switchgear contains fused interrupter switches that supply the Archives Building, the Boiler Plant, State Office Building West vault, State Office Building East vault, the Capitol Building chiller, and the Capitol Building.

The Archives building feeder consists of 3 each #2 awg (American Wire Gauge), EPR insulated, 15 kV, copper conductors and 1 #6 copper conductor in an overall armored cable sheath that is PVC coated. The interrupter switch that is used to protect these conductors is a fusible switch with 20 amp fuses. The cable terminates in a 225 kva (kilovolt amperes), 12,470 - 120/208 volt transformer that is used to supply the main distribution panel in the Archives Building.

The Boiler Plant feeder consists of 3 each #2 awg, EPR insulated, 15 kV, copper conductors and 1 #6 copper conductor in a 4-inch non-metallic duct with concrete encasement. The interrupter switch that is used to protect these conductors is a fusible switch with 20 amp fuses. The cable terminates in a 300 kva, 12,470 - 277/480 volt transformer that is used to supply the main distribution panel in the Boiler Plant. The Boiler Plant distribution system is also used to supply power to the Greenhouse.

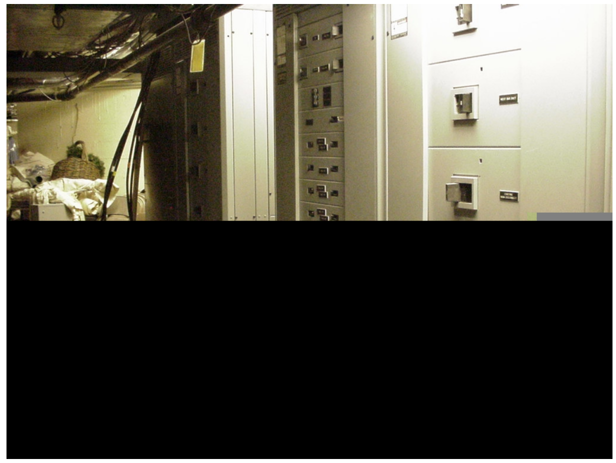
The State Office Building East and West vaults are each supplied by separate 3 each #2 awg, EPR insulated, 15 kV, copper conductors and 1 #6 copper conductor in overall armored cable sheaths that are PVC coated. The interrupter switches that are used to protect these conductors are fusible switches with 125 amp fuses. These feeders each terminate in interrupter switches with 50 amp fuses. These interrupter switches are used to supply a bank of 3 each 250 kva, 12,470 - 277/480 volt transformers.


MEDIUM VOLTAGE FEEDER ATTACHED TO BASEMENT CEILING

The remaining feeder from the metalclad switchgear is used to supply the State Capitol Chiller and the State Capitol Building. The feeder consists of 3 each #2 awg, EPR insulated, 15 kV, copper conductors and 1 #6 copper conductor in an overall armored cable sheath that is PVC coated. The interrupter switch that is used to protect these conductors is a fusible switch with 125 amp fuses. The feeder is installed within a tunnel system between the switchgear room and the Capitol building basement. The feeder enters the Capitol building at the west end of the basement where it terminates in an interrupter switch with 40 amp fuses. The medium voltage feeder within the Capitol building is supported from the basement ceiling structure using porcelain insulators and it is visible in the corridors of the basement. The interrupter switch is used to supply a 500 kva, 12,470 - 4,160 volt transformer that is used to supply the Capitol Chiller. The feeder is tapped ahead of the interrupter switch to supply another metalclad switchgear that is located outside of the Capitol Building near the northeast corner between the Capitol Building and the Service Station (the Service Station has since been demolished). The metalcald switchgear contains 2 interrupter switches. One interrupter switch has 20 amp fuses and is used to supply a 300 kva, 12,470 - 120/208 volt transformer. The second interrupter switch has 50 amp fuses and is used to supply a 1000 kva, 12,470 - 277/480 volt transformer. The feeders to each transformer consists of 3 each #2 awg, EPR insulated, 15 kV, copper conductors and 1 #6 copper conductor in a 4-inch non-metallic duct with concrete encasement.

2. Capitol Building Electrical Service and Distribution

The secondary (low voltage side) of the 1000 kva, 480/277 volt transformer supplies a 1600 amp main circuit breaker switchboard section that is located in the basement electrical room. This switchboard was installed in 1982 to replace existing main breakers and it is used to supply the older switchboard sections as well as newer switchboard sections that were installed at the same time. The distribution sections contain circuit breakers that supply lighting and appliance panelboards on all levels. Some of the feeders are used to supply 480 - 208/120 volt stepdown transformers located throughout the Capitol. In 1992 a project was designed to replace all of the existing 480/277 volt switchgear and install 480/277 volt busways to distribute power to all levels; however, this project was never constructed.



EXISTING ELECTRICAL DISTRIBUTION SWITCHBOARDS

The secondary of the 300 kva , 208/120 volt transformer supplies a 1000 amp main circuit breaker switchboard section that is located in the basement electrical room. This switchboard was installed in 1982 to replace existing main breakers and it is used to supply the older switchboard sections as well as newer switchboard sections that were installed at the same time. The distribution sections contain circuit breakers that supply lighting and appliance panelboards on all levels. In 1992 a project was designed to replace all of the existing 208/120 volt switchgear and install 208/120 volt busways to distribute power to all levels; however, this project was never constructed.

3. Emergency Power System

There are two 750 kw diesel generators located in a building that is just east of the switchgear building. These generators are used primarily to supply standby power to the Data Processing Center. There is a 60 amp, 277/480 volt feeder that runs from the standby power system to the Capitol Building to supply the Governor's office and a few other receptacles within the Capitol. There is no additional emergency power available within the Capitol. The 1992 project that was designed but not constructed would have included a 400 amp emergency distribution system using the existing generators. There is also a Uninterruptible Power System (UPS) located east of the generators. The UPS is used to supply power to the Data Processing Center and is not used by the Capitol Building.

4. Existing Wiring Methods

Although the Kletting drawings show the lighting we can find no positive evidence that any receptacles were included in the original construction. This would not be unusual since there were very few plug-in devices available at the time of construction. There is some indication on Sheet Number 8 of the Kletting drawings that floor boxes were placed in the Senate, House, and Supreme Court but it is unclear whether these were used for receptacles or lighting. It is suspected that they were intended to be used to supply power to desk lamps. These floor boxes have been removed or covered by renovations and new power has been run to desks in the House, Senate, and Supreme Court Chambers.

It is suspected that some of the original wiring may still remain in place; however, our survey did not uncover any of the original wiring. We did find that some of the original conduits are still being used but the wiring within the conduits has been replaced. The original wiring consists mostly of copper conductors installed in black iron conduit. Within finished areas the original conduits and outlet boxes (outlet boxes are steel boxes that are used for connection of wiring to light fixtures, receptacles, etc.. they also contain screw holes that used to fasten these devices in place) were embedded within the concrete slabs. The conduits and outlet boxes were installed this way so that the light fixtures could be fastened directly to the bottom side of the concrete slabs. This is significant because in order to bring the ceilings back to the original state the new conduits and boxes will need to be installed in the same way. During the initial construction the conduits and boxes were installed prior to pouring of the concrete. Renovations will require removal of concrete so that existing conduits and outlet boxes can be replaced by new conduits and outlet boxes.

PANELBOARDS IN OCCUPIED SPACE

The original construction made use of circuit boards that used knife switches and edison type fuse holders (edison type fuse holder look like lamp sockets) for connections to circuit wiring. We could not find any of these panels still in use but we did find an abandoned panel of this type behind the dome approximately at the level of the first ring. We did find circuit breaker panels, which were not available at the time of the original construction, at several locations. The age of these panels ranged from 75 years to almost new. Obviously there were no electrical rooms planned to contain circuit breakers; therefore, several have been installed within occupied spaces. Others have been installed in rooms that were probably originally intended to be used as storage rooms. The panels are extremely disorganized and it is difficult to discern the areas that are covered by each panel. This makes it difficult or impossible for maintenance personnel to identify circuit problems in a reasonable period of time.

Wiring that has been added after the original construction is, in many instances, fastened below the original finishes. In some areas there appears to be a few layers of wiring which indicates that there have been several electrical renovations and abandoned wiring has not always been removed.

5. Existing Lighting

During the period when the Capitol was designed and constructed, lighting levels that were encountered within buildings were much lower than lighting levels that are encountered today. Most of the lighting was used as decorative elements, specific task lighting within a space such as an office, or hidden within the architecture such as coves and skylights. Electric light sources that were available at the time were uncomfortable, by today's standards, from a heat and glare perspective.

NONFUNCTIONING COVE LIGHTING IN ROTUNDA

ABANDINED LIGHTING BELOW THE ROTUDA FLOOR

On the first floor most of ambient lighting is provided by display case lighting. The original construction included ceiling mounted lighting in the exhibition and corridor spaces. Much of this lighting has been removed.

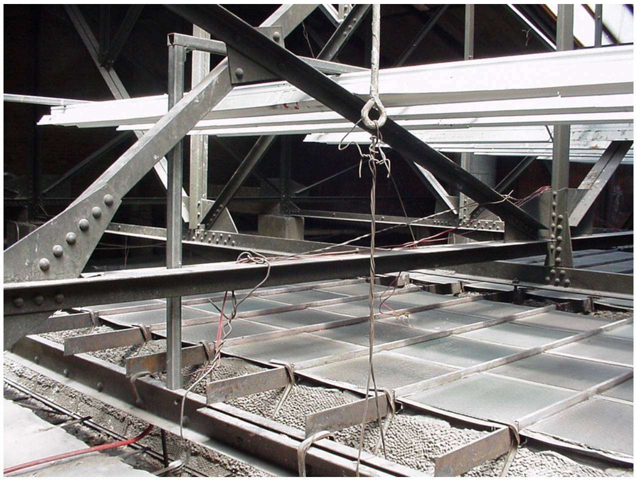
Lighting in the Rotunda is provided by a large pendant fixture that was originally fitted with incandescent lamps. The original lighting included coves at two levels; however, the lamps for these fixtures have been removed and they are no longer in use. The fixtures remain in place but they are not in working order. The murals that are found on the dome are not illuminated as originally intended because these cove lights have been removed. Originally the Rotunda floor consisted of glass panels that allowed transmission of light to the first floor. Additionally there were lamps installed below the glass panels at the first floor ceiling. These lamps could have been viewed from the second floor through the glass panels and may have provided some illumination through the glass panels. The lamps and most of the sockets have been removed and the glass panels have been replaced by opaque panels so that light is no longer transmitted between floors.

Illumination in the east and west stairways is provided by highly decorative fixtures that are mounted on top of the newel posts. The only other illumination is provided by the skylights at the east and west ends. There are no artificial light sources above these skylights; therefore, after dark lighting of these stairs is minimal.

Egress lighting throughout the building is inadequate or non-existent. Current codes require a minimum illumination of 1 footcandle in all paths of egress. The building emergency lighting falls well short of this requirement.

Fortunately many of the lighting fixtures that were originally installed in public areas remain in place today.

The House, Senate, and Supreme Court chambers have significant skylights that provide a significant source of daylighting in these rooms during the daytime. Fluorescent strip fixtures have been installed above the skylights in the House and Senate Chambers to provide for an artificial light source after dark. Artificial lighting above the skylights was originally provided by incandescent light sources. Incandescent light sources are still used above the skylights in the Supreme Court; however; it is not known whether these are original light fixtures or not. Regardless of whether these sources are new or original they provide for very spotty lighting above the skylights. In all chambers the artificial lighting above the skylights is controlled by a manual switch that is located in a closet near each room. In addition to the skylights there are lighted coves and wall sconces that provide additional illumination within the House and Senate Chambers. The Supreme Court Chambers has wall sconces but does not have a lighted cove.



FLUORESCENT LIGHTING ABOVE THE SKYLIGHTS IN SENATE CHAMBERS

Renovations within several of the office areas have made use of suspended "T" bar ceilings. Lay-in type 2 ' x 4' fluorescent fixtures have been used to provide lighting in these office areas. Evidence found above the lay-in ceilings reveals that chandeliers or pendant light fixtures were originally used to provide illumination within offices. Historic photographs of the building show that there were some differences in the chandeliers and pendant lights originally provided - presumably in line with the "rank" of the occupant, or the use of the room. These light fixtures were suspended from outlet boxes that were cast into the concrete slabs above. When the suspended ceilings were installed the original outlet boxes and the conduits that provided a wiring pathway to the outlets were abandoned in favor of new wiring that was installed in the space between the lay-in ceiling and the original concrete slabs. Obviously the fluorescent fixtures that are used in these office spaces are out of character with the historic nature of the Capitol building.

TYPICAL SITE LIGHITING FIXTURE - ONE OF MANY STYLES FOUND AT CAPITOL

In the Governor's Boardroom lights have been installed to provide additional lighting that is required for the use of television cameras. Much of this equipment is portable and is brought out only when required.

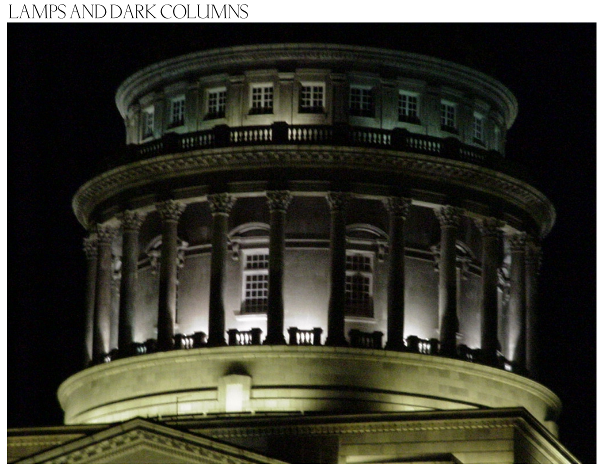
The site is lighted with a conglomeration of old lighting, reproductions of old lighting, and new institutional lighting. These provide insufficient lighting for safe walking and driving on the grounds. Even among the historic appearing light fixtures there are inconsistencies in style and appearance. The building mounted fixtures at the east end of the building may be original but the pole mounted site lighting

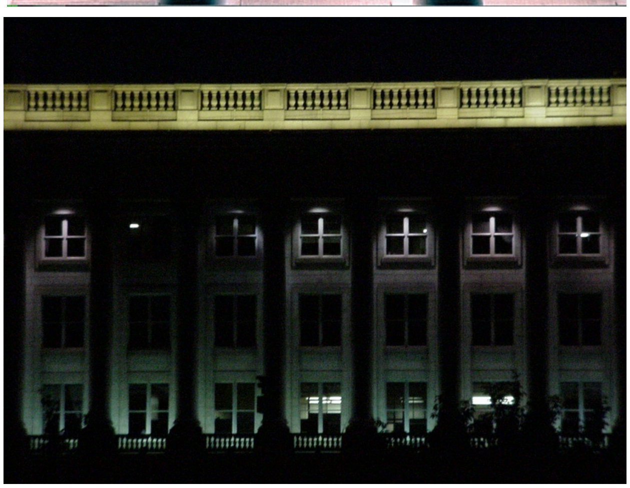
fixtures are not original.

The building facade is lighted with building mounted floodlights at the windows, eaves, cornices, roof, and dome. These were added within the last ten years. The mounting position of these lights creates several problems including glare to occupants, uneven facade lighting, and serious maintenance problems. Facade lighting sources include metal halide lamps and fluorescent lamps. For the most part the metal halide flood lights are not difficult to access and maintain. On the other hand the location of the fluorescent light fixtures makes maintenance very difficult. Perhaps this is the reason that burned out lamps are not replaced immediately leaving a very noticeable dark spot in the facade lighting. The color temperature and color rendering index of metal halide and fluorescent sources are quite different which provides for an inconsistent appearance of the facade lighting. Many of the metal halide fixtures have worn cords and yellowed lenses.

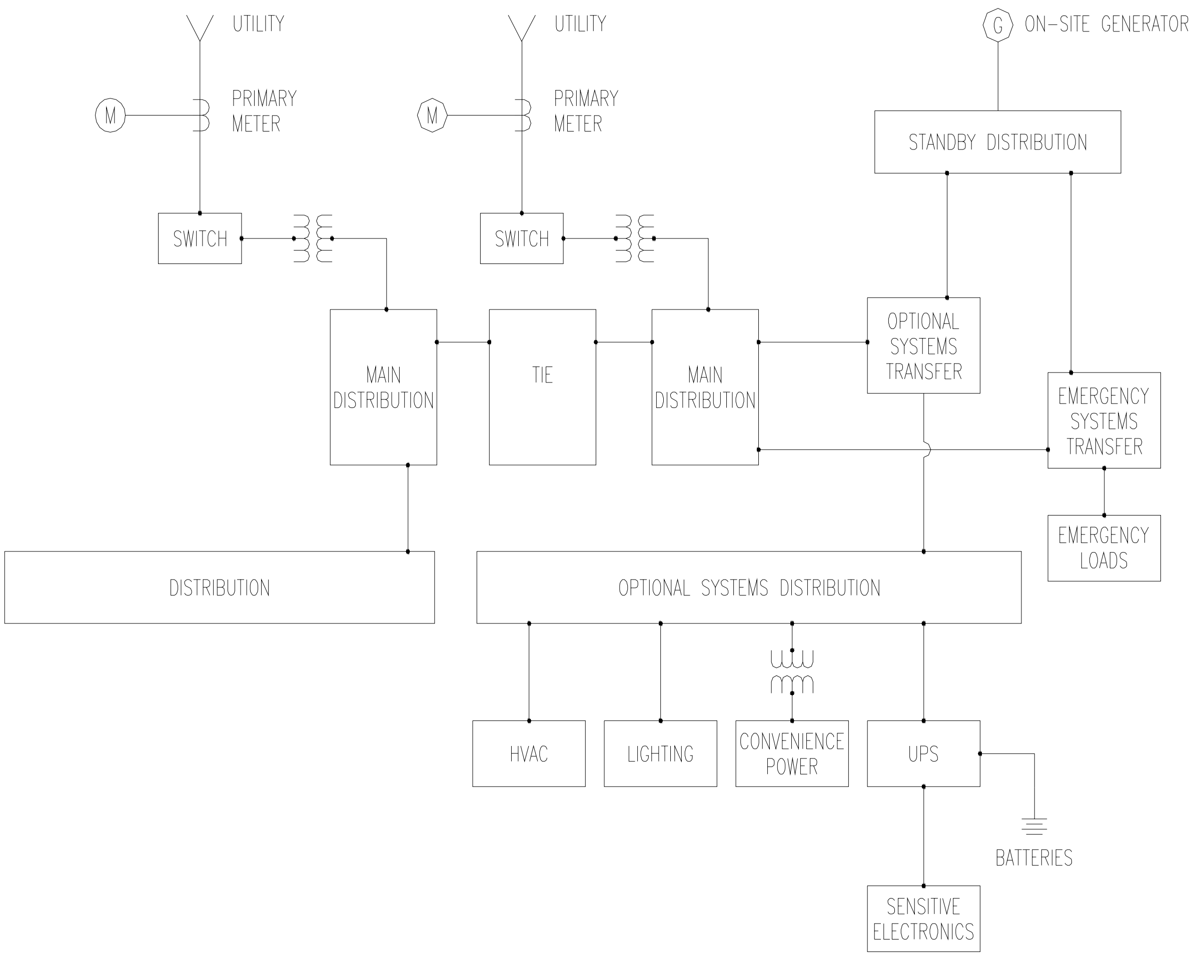
A survey of measured illuminance of existing equipment, can be found in the appendix.

FACADE LIGHTING - NOTE THE SHADOWS CAUSED BY BURNED-OUT LAMPS AND DARK COLUMNS





1. Electrical Systems



DOUBLE-ENDED ELECTRICAL DISTRIBUTION SYSTEM

a. A primary metering cabinet was installed so that all buildings on the Capitolgrounds could share a single meter. This was done to obtain a lower billingrate from Utah Power. Although billing practices by Utah Power have changed there is still an advantage to using primary metering due to the combining of peak power demand from all buildings. Although primary distribution equipment does require some maintenance by the State the maintenance is relatively minor.

b. The primary switchgear and transformers are 12 and 18 years old respectively and they probably have significant useful life remaining. The metalclad switchgear that is used for primary distribution is relatively unchanged in the last 12 years and will probably not change in the near future. The transformers typically do not require replacement parts; however, more efficient transformers are available. The use of high efficiency transformers can reduce power consumption and operating costs.

c. The provision of padmounted transformers located outside of the building is a good practice. Traditionally a single 12,470 - 480/277 volt transformer is provided outside and one or more 480 - 208/120 volt transformers are provided inside. The current arrangement with both transformers located outside is good because the transformers do not add to the heating load of the building. A disadvantage with the 12,470 - 208/120 volt transformer located outside is that the feeder conductors may need to be increased in size to prevent voltage drop due to excessive length. Also, because the 208/120 volt transformer is not supplied downstream of the 480/277 volt transformer it is difficult to use it in an arrangement that includes standby power.

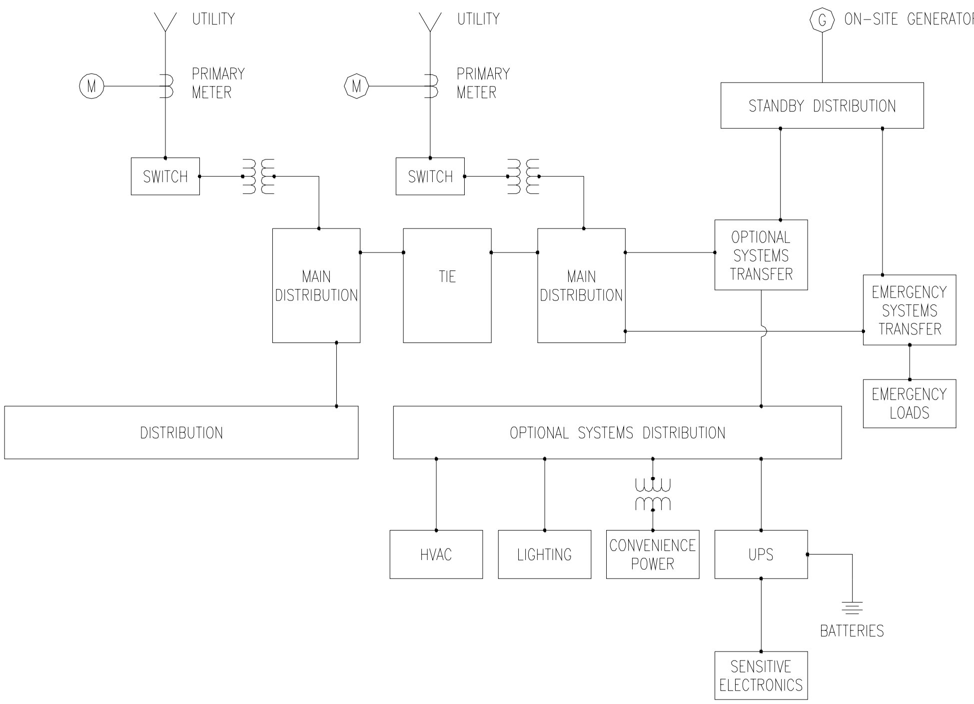
d. Both the 480/277 volt and the 208/120 volt systems are supplied by single transformers. This means that a failure of one of these transformers or one of the overcurrent devices that is downstream of the transformers could cause an extended power disruption. In contrast both the Ohio State Capitol and the Texas State Capitol were constructed with double-ended distribution systems. Double-ended systems have a transformer at each end which provides for added reliability and serviceability. A double-ended system requires failure of two transformers or overcurrent protective devices, a highly unlikely scenario, to cause a power outage. A single-ended system, such as the current system, allows a single failure to disrupt power to the entire system.

e. The inside distribution system switchboards are a patchwork of relatively new main disconnects and distribution sections with older distribution sections. Given the age of the switchboards the risk of irreversible damage to the older switchboards during renovation is high. Obtaining replacement parts for the older distribution sections is difficult today and will become even more difficult with passage of time. The fault current interrupting capacity of the existing distribution equipment may be inadequate for increased available fault currents that could result from replacement of transformers upstream of the distribution system.

f. The new electrical distribution system should be as compact as possible to conserve space and should be flexible to allow for future modifications. A flexible system should have spare capacity and should be accessible to all areas of the building. The existing electrical distribution system is very limited in flexibility and additional space. Access to the existing distribution system, especially to floors above the basement, is extremely limited.

g. There should be a separation of distribution systems to provide “clean” power to building electronic systems, information systems, and computer work stations. The “clean” power distribution section should be isolated from the normal “dirty” power distribution section. A system that is configured in this way will reduce hardware and software errors.

h. Electrical equipment that is used for control of motorized equipment, such as air-handlers and pumps, can be consolidated into motor control centers to provide easy access by maintenance personnel. Motor control centers containing starters, variable frequency drives and filters, indicating lights, disconnects, overload protection, and overcurrent protection can be installed at a few loca-



DOUBLE-ENDED ELECTRICAL DISTRIBUTION SYSTEM

tions, as opposed to scattering these items. This consolidation will help to reduce maintenance costs and will allow for quicker response time when a problem occurs. The best location for motor control centers is in the basement and attic where they will be close to the mechanical equipment.

i. The functions that take place in the Capitol building require a large gathering of people and resources during a restricted time period. Power outages that render the building inoperable during these times can cause interruptions with far reaching consequences. For this reason it is important that the building is capable of being occupied and operated during normal power system outages. To accomplish this requirement an on-site standby generator is needed to supply power during utility outages. The Ohio State Capitol has a generator that provides standby power to the entire building. The Texas State Capitol has a set of generators that provide standby power to all lighting and enough power to selected outlets to keep the sessions going but does not supply standby power to the air conditioning equipment. Emergency and Optional Standby power systems should be provided and should be separated as required by National Electrical Code 1999 (NEC), Article 700. The emergency system is required by NEC to provide backup power for systems that are essential for safety to human life such as egress lighting, exit sign lighting, smoke control, and fire alarm. The optional standby system is not mandated by code but is provided so that the building can be occupied and used during utility power outages. Equipment that can be connected to the optional standby power system includes area and task lighting, convenience receptacles, air-handling equipment, security systems, and communications systems. To obtain maximum usage of the generator a load shedding scheme should be employed. A load shedding scheme is used to connect as much of the building as possible to the generator during an outage. The loads are separated into non-essential, essential, and critical. When the generator starts to become overloaded the non-essential loads, and if necessary the essential loads, are shed so that the generator can supply power to the critical loads. The load shedding scheme can be accomplished using multiple transfer switches or switchgear with motor operated circuit breakers that are capable of automatic remote control.

j. When a utility power outage occurs there is a brief period of time when the transfer equipment is switching between the utility source and the on-site generator. Although the switching occurs in less than 10 seconds, computerized systems will experience an outage and will need to restart. Any information that was not saved is lost. In addition unexpected outages often cause network data errors. An Uninterruptible Power Supply (UPS) system that is backed up by batteries can be used to carry computers through outages for a brief period of time, usually 15 minutes, with no interruption thereby eliminating the need for a restart. This is an adequate amount of time to allow the on-site generator to be brought on line automatically and then pickup the computer load. When a UPS system is used power outages are transparent to computerized equipment that is connected downstream of the UPS. A UPS provides an added benefit in that its output is a source of “clean” electrical power that helps to reduce computer errors and hardware damage.

k. Raceways that have been installed below original ceilings will need to be removed or relocated so that the original ceiling can be reestablished. Use of existing black iron conduits, even those that are embedded within concrete slabs, will be risky because these raceways are no longer manufactured and it is impossible to find parts that are listed for use with these raceways. Black iron raceways are no longer a recognized conduit system. New raceways that are used to supply wiring to light fixtures at original positions will need to be cut into existing concrete slabs. This practice was employed extensively at both the Ohio State Capitol and the Texas State Capitol. At both of these locations the floor covering was removed, the concrete was cut and removed (at Ohio there was rubble in place of concrete), the new conduits were placed, and then a slurry mix (rubble in Ohio) was poured over the conduits.

l. The new electrical distribution should be designed to minimize the quantity of horizontal conduit runs for both branch circuit and feeder wiring. To aid in organizing and tracking circuits there should be a clear area of coverage for each panel. Stacking of electrical rooms or providing several electrical rooms in the basement and attic area will go a long way towards reducing the quantity of horizontal wiring runs that are needed but only if adequate vertical wiring chases are provide. Chases that are provided for branch circuit wiring should be accessible and should be of adequate size to allow for new and future installations.

m. Wiring systems that are utilized should be flexible and allow for modification with little or no damage to finishes. As much as possible the circuits and raceways should be provided in anticipation of additional power consuming devices and appliances. Electrical equipment, such as circuit breaker panels and lighting control panels, should be installed in electrical closets so that it does not interfere with future renovations, does not detract from the historical nature of the building, and is not susceptible to vandalism. The Physical Security Survey provided by Mr. Greg Rollins recommends that electrical boxes, wires, and rooms should be secured by alarms and locks. This can only be accomplished by installing electrical equipment in secured electrical rooms or closets.

n. Modern computer environments require a good grounding system in order to function properly. In conjunction with the grounding system a lightning protection system can be used to reduce the risk of damage to computerized equipment due to lightning strikes. The lightning protection system also provides protection for the structure and the occupants. A transient voltage surge suppression system (TVSS) can be used to provide protection against voltage surges and spikes that are caused by lightning and other disturbances on power lines.

o. Replacement of the existing boiler plant with a new Central Heating and Cooling Plant will require some modification to the Capitol Grounds Electrical Distribution System. Relocation of chillers from the Capitol and State Office buildings will reduce the load on the electrical systems for these buildings. At the same time the Central Heating and Cooling Plant will have an electrical load that is higher than the current Boiler Plant load. To accommodate this higher load a new medium voltage feeder and transformer will need to be provided for the Central Heating and Cooling Plant.

p. Provision of standby power to the Capitol Building will maintain power to the building but will not provide power to other buildings such as the new Central Plant. This means that during extended power outages the Central Plant will be unable to keep up with the heating and cooling requirements of the Capitol Building. This could be overcome by providing standby power to the Central Plant; however, this would be a costly and impractical solution. An alternative solution would be to install separate small cooling systems within the Capitol Building to cool vital computerized equipment. These smaller systems could be backed-up by the Capitol Building standby system at relatively low cost. Most of the air handling systems within the Capitol Building will already be backed up by standby electrical power systems because they will be needed for smoke control.

2. Lighting

a. As we have previously stated, historic lighting levels were much lower than current practice. Old lighting technology is incompatible with today's tasks and technical requirements for lighting. Today office tasks are computer oriented and require the use a computer monitor. Lighting must be designed with care to be compatible with monitors. Inappropriate lighting causes glare in monitor screens that make them difficult or impossible to view. In addition inappropriate lighting can lead to eyestrain and worker discomfort. In the modern workplace there is an expectation that the lighting will be appropriate, by today's standards, for the tasks that will performed.

b. A goal of the restoration of the Utah State Capitol should be to restore the public areas to the appearance and decor of the initial construction, within the bounds of safety (no gas lamps, code required emergency and egress lighting, for example). Fortunately most of the public rooms, including the House and Senate chambers, have significant skylights, which are supplemented by artificial lighting to emulate daylight thru the skylights at night. These skylights provide most of the illumination required during the daytime. The traditional (low) lighting levels are therefore mitigated in these areas by the natural or supplemented skylights.


SKYLIGHT IN SENATE CHAMBERS

c. Supplemental lighting, such as that found above the skylights in the Senate and House Chambers, does not carry throughout the whole building, so lower lighting levels can be found in important places like corridors, foyers, etc. It is problematic that these lower lighting levels are also found on some stairways. These areas require additional lighting from theme-styled fixtures in order to comply with code mandated lighting levels. The light fixtures within corridors, stairways, and exitways do not always maintain proper emergency exit lighting. The lighting in these areas needs to serve the dual purpose of providing ambient lighting and emergency egress lighting.

d. Much of the historic lighting fixtures in public areas remain in place today and can be restored to provide decorative and ambient lighting from original or period lighting fixtures. Such restoration and renovation of the lighting fixtures should include current lamp technology that will increase the amount of light, decrease the required maintenance, and use less electricity. As an example compact fluorescent lamps, which produce light that is indistinguishable from the light that is produced by incandescent lamps, can be used to replace the incandescent lamps.

e. Photographs show that original lighting in many rooms still exists and these fixtures are available for restoration. These areas are identified in this report as Preservation Area I.


ROTUNDA CHANDELIER

f. Some of the offices around the perimeter of the building have been renovated using suspended "T" bar grid ceiling systems with recessed fluorescent light fixtures. Evidence found above the dropped ceilings reveals that originally there were 2 chandeliers or pendant lights per office. These chandeliers have since been removed. The current lighting presents a glare problem for today's computer oriented office tasks. The new lighting must be compatible with computer vision and complex audio/visual systems yet maintain some sense of the historic restoration in appearance. These areas are identified in this report as Preservation Area II.

g. Other areas, generally considered "support" spaces, such as the basement, require the lighting be replaced with appropriate and efficient lighting, using the lamps that are required elsewhere in the building. These areas are identified in this report as Rehabilitation Zones or are not mentioned.

h. In selected areas there are lights installed to provide the increased illumination that is required by television cameras. Much of this equipment is portable and is brought out when required. Elements of the TV lighting, such as receptacles and mounting hardware, remain in the rooms when not in use. The use of television is increasing, and the areas requiring television lighting are increasing, so lighting suitable for broadcast needs to be provided in additional areas. Trip hazards and other undesirable side effects presented by portable equipment can be reduced by installing permanent television lighting in lieu of allowing camera crews to bring in their own equipment. In rooms where television broadcasts will originate, fixed lighting can be provided to meet all lighting requirements. This will eliminate the need for crews to bring in their own equipment thereby eliminating the trip hazards that they cause.

AN EXAMPLE OF ORIGINAL LIGHTING

i. The site is lighted with an assortment of old--but not historic--lighting, which is not coordinated or even visually compatible. These provide insufficient lighting for safe walking and driving on the grounds. Although there is sufficient lighting for most security cameras, it is necessary to completely renovate, perhaps replace, the site lighting to provide a coordinated lighting system with comprehensive coverage, and to have a suitable appearance, complementing the restoration. These new lights will be required to control light trespassing into the neighbors' property.

FACADE FLOODLIGHT

j. The building facade is lighted with building mounted floodlights and linear fluorescent sources at the windows, eaves, cornices, roof, and dome. There are several problems with these, including glare to occupants, uneven facade lighting, and difficulty in maintenance. New lighting must solve these problems. By placing the existing floodlights immediately outside the windows, the light from these floodlights enters the room, and makes the night view out of these windows useless. Furthermore, by placing the lights so close to the building, the columns between the windows are lost in shadow. Floodlights placed further from the building would light the entire facade, including the columns, with less glare from lights that are much further from the building. Lighting of the entire facade and columns in this way would provide for a more dramatic lighting effect that would show off the beauty of the Capitol building. The same holds true for the dome. Lights placed further away from the structure, either on the roof or on the ground, would more evenly light the dome, which would eliminate, the dark band around the dome columns. Some of the access problems cannot be eliminated, since some of the cornices and dome lighting cannot be improved, but the vast majority of the new lighting fixtures should be easily accessible.

1. Electrical

a. Replace existing electrical distribution system: The new electrical distribution system should be configured to provide a separation of services based on the load that is served. As an example feeder circuits that are used to supply HVAC equipment should be separated from circuits that are used to supply electronic equipment. The separation of services is a first step towards providing "clean" power to sensitive loads.

b. Install Emergency and Optional Standby power distribution system with standby generator to serve the Capitol Building: Emergency power distribution systems are required by code for systems such as egress lighting, elevators, and smoke control. Optional Standby power systems should be provided for security systems, communications systems, and as a backup to Uninterruptible Power Supplies.

c. Install Uninterruptible Power Supply (UPS) with distribution throughout the Capitol building: UPS system equipment should be located in the basement and should be distributed to all electrical rooms.

d. Replace existing 300 and 1000 kva transformers with more efficient models: It is possible that energy savings could be realized by replacing the existing transformers with new high efficiency, liquid filled transformers. The liquid should be non-toxic, non-bioaccumulating, readily biodegradable and should have a high fire point.

e. Replace existing 300 and 1000 kva transformer with a single transformer to simplify connection to standby power system: The standby generator typically replaces the transformer when a power system is operating in standby mode. The generator has a single output voltage; therefore, it is impractical for a single generator to backup two transformers that have different output voltages. Replacing the two existing transformers with a single transformer having a single output voltage will simplify and reduce the cost of a standby system.

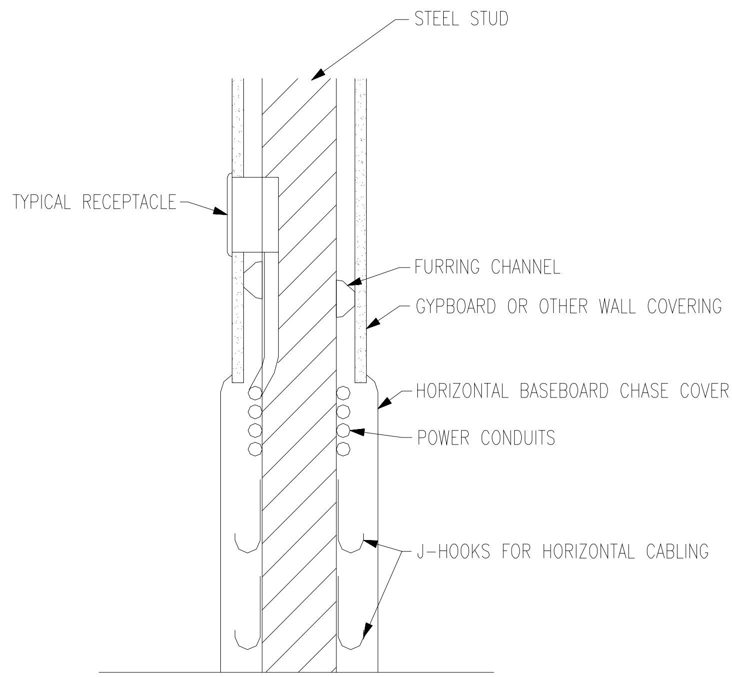
f. Provide two new transformers and configure the electrical service and distribution into a double-ended system with greater reliability.

g. Remove all medium voltage (12,470 and 4,160 volt) wiring from inside of building: Removing medium voltage cables from inside of the building will lower the risk of damage to the cables and will reduce the response time if the cables are damaged.

h. Replace all existing wiring: Conduits that are embedded and cannot be replaced without damaging historical finishes should be reused if possible; however, all other conduits and conductors should be removed and replaced. Replacement of all existing conductors , even in the embedded conduits, will ensure that the insulation of all wiring will be adequate for several years into the future.

i. Establish electrical rooms in each quadrant and stack rooms vertically: Electrical rooms at each quadrant will need to be approximately 120 square feet. Stacking of electrical rooms will provide a horizontal wiring path that will not disturb existing finishes. Providing rooms at the quadrants will minimize the horizontal wiring.

j. Establish electrical rooms in basement and attic levels along the building perimeter and use chases at each column and new shear wall to run wiring vertically. Install horizontal wiring between the electrical rooms and chases at the basement and attic ceiling levels. Provide horizontal wiring chases in new walls at each level to distribute wiring at each level.



HORIZONTAL WIRING CHASE

k. Install electrical equipment only in electrical rooms: Electrical equipment such as panelboards should be confined to electrical rooms. Doing so will reduce the maintenance response time and will assure that electrical equipment does not detract from the historic appeal.

l. Conceal horizontal raceways within architectural finishes: To preserve the historical finishes all raceways and cabling must be concealed within the finished walls and ceilings. This will allow installation of light fixtures at original locations and will allow ceilings to be returned to original elevations.

m. Install accessible flooring in House and Senate Chambers to increase the flexibility of the electrical and communication system wiring: Accessible flooring raised only 1 inch above the floor provides a convenient system for installation of horizontal power wiring and communications cabling.

Modular wiring systems used in conjunction with accessible flooring are easily concealed and are simple to modify as the technology changes.

n. Provide a lightning protection and grounding system. A lightning protection system is needed to protect the structure from damage due to lightning strikes. The risk for a lightning strike at the Capitol is high, mostly due to the fact that it is the tallest structure in the area.

2. Lighting

a. All historic lighting fixtures in public areas will be energy - improved restorations of existing fixtures or new replicas, and must look authentic. Longer life compact fluorescent lamps shall be fitted into uplight compartments of restored lighting fixtures where possible, to provide for reduced maintenance and reduced energy consumption. Mock-ups of such relamping shall be made to determine the appearance of the new lamps thru the glass lenses, to avoid unnatural lamp images. Over the years, this has been done in some areas.

b. Designated historic lighting fixtures in the House, Senate and Supreme Court shall be rewired for safety, but maintain visible incandescent lamps.

c. The existing skylights shall have new energy efficient lighting installed above them, replacing the original incandescent lamps and subsequent. The use of skylights to provide daylighting with artificial light sources to provide after dark illumination was an interesting design element, that was quite advanced for it's day. Existing cove light systems will be renovated and reused.

d. Offices need to lighted for today's computer oriented workers. "Historic" or replica lights, with lamps to generate 50 fc of light at task from these indirect luminaires, should be used here. Task lights will be needed in private offices.

e. Install historic or replica light fixtures in stairwells and corridors to meet current IES recommendations and egress lighting requirements per code. Supplement existing or historic lighting positions with new fixtures.

f. Replace the existing relay and or dimming control systems in House, Senate, and elsewhere. The existing systems are antiquated and should be replaced by newer systems that can be interfaced to audio/visual and building automation systems to provide for automatic control.

g. Replace the preset dimming system for House, Senate, Committee Rooms, Gold Room, Supreme Court, etc. The new system should offer multiple presets, allowing tour guides to demonstrate "original lighting" levels, and to automatically adjust for the presence of daylight from the skylights.

h. Certain areas that have had incorrect lighting renovations should have new lighting added, where original lighting cannot be obtained. The changing needs of lighting to be compatible with today's technology, should be observed wherever possible in non-presentation spaces. For instance, Senate and House galleries should be lighted with outward facing coves, lighting the ceiling, but providing no direct lamp image or glare. Another example is the use of limited downlight and mostly uplight in the office areas, where yesterday's paper tasks have fallen to today's use of computers, and the need to control a different type of glare. Additionally certain prior renovations obliterated desirable architectural features, lighting needs to be restored in concert with the restoration of these features.

i. Certain elements of the site lighting recreate the theme of the original lighting. These post-top luminaires need to be duplicated from commercial sources, and installed on each walkway and circulation feature (steps, ramps, passenger drop-offs, etc.) with a density sufficient to assure a maintained illuminance level of .5 fc. These should use metal halide sources to match the facade lighting. The poles should be no higher than 14 feet, using a cast iron decorative pole and base.

j. The parking lots should be illuminated to a .5 fc maintained minimum illuminance level using IESNA classified " full cutoff" luminaires. These should use metal halide sources to be consistent with the facade lighting.

k. The Capitol building facade should be illuminated to a level consistent with the current IESNA recommendations, using metal halide sources. Floodlights for the facade should be mounted on poles around the perimeter but should not be building mounted. The floodlights for the dome should be roof mounted. This floodlighting should be done with metal halide sources, to complement the natural color of the granite.

l. There should be separate lighting control equipment for each of these lighting systems.

1. Replace existing electrical distribution system: Parts of the existing electrical distribution system are outdated and require replacement. Other parts of the electrical distribution system are newer and could be reused; however, the cost of reusing existing equipment, in terms of dollars, time, and functionality are too high. In addition seismic upgrades to the foundation and footings will probably require removal of the existing equipment so that the foundation and footings can be accessed. It is recommended that the renovation should include a new electrical distribution system. The new distribution system should be located in the basement of the building as close as possible to the location of the service entrance (near the transformers). Due to limited space within the basement the distribution system overcurrent devices will need to be circuit breakers which require less space than fuses. Circuit breakers rated over 400 amps should be solid state type with adjustable instantaneous, short time, and long time trip functions and ground fault protection where required.

2. Install Emergency and Optional Standby power distribution system: The emergency power system is required by code to provide standby power for lighting and smoke control systems. A standby generator and transfer equipment will need to be installed to comply with code. The optional standby power system is not code required but is recommended to provide standby power so that the building can be operated and occupied during power outages. It is recommended that the standby power systems should be sized to run the entire building.

3. Install an Uninterruptible Power Supply (UPS) system with distribution throughout the Capitol building: Computerized equipment cannot tolerate even brief power outages. To overcome this intolerance a UPS can be used to ride through transfers between normal power sources and emergency power sources. The UPS provides the additional benefit of providing clean a "clean" power source for computerized equipment. It is recommended that a UPS should be installed in the basement of the building and it should be used to supply power to communications equipment and personal computers throughout the building. The DC power source for the UPS should be valve-regulated lead-acid batteries; however, the design phase should include an analysis of available sources. Recent developments in fuel cell technology indicate that fuel cells may become a viable and economical DC source for future UPS systems.

4. Replace the existing 300 kva and 1000 kva transformers with two new energy efficient transformers and configure the electrical service and distribution in a double-ended arrangement. Energy efficient transformers will lower the operating cost. The double-ended arrangement will increase the reliability of the electrical system and will reduce the duration of some power outages.

5. Remove all medium voltage (12,470 and 4,160 volt) wiring from inside of building: The medium voltage cables that are hung from the basement ceiling will almost certainly be disturbed by the seismic upgrades. The medium voltage cables were probably installed within the building mainly to supply the old chiller. It is recommended that the cables should be removed from inside of the building. The medium voltage feeder will still need to be installed in the tunnel between the physical plant and the Capitol building. It is recommended that the transformers, discussed above, should be placed on or near the tunnel to provide easy access to the medium voltage cables. The switchgear that will be needed should be metalclad or padmounted and should also be located near the tunnel.

6. Replace all existing wiring: Existing wiring, including branch circuits and feeders, that is left over from the original construction is beyond its useful life and should be replaced. Where possible the conduits that are concealed behind finishes that will not be removed can be reused if in compliance with current codes. Existing wiring that was added after the original construction may be in good working order but it is installed in a

highly unorganized manner. It is recommended that all wiring and conduits that were installed after the original construction should be removed. This will allow the architectural finishes to be returned to their original condition without conflicting with the wiring. There are cost savings both initially and over the life of the building that can be realized by organizing the new wiring.

7. Establish electrical rooms in basement and attic levels along the building perimeter and use chases at each column to run wiring vertically: During the renovation the largest challenge facing the electrical installer will be in running wiring horizontally at the first, second, and third levels. If the historical ceiling levels are to be maintained then a means of installing wiring that is concealed within the walls needs to be established. It is recommended that a horizontal wiring chase should be constructed in every wall where a power, lighting, communications, or security outlet may be installed in the future. The chase should contain a means of supporting communications and security cabling, such as J-hooks, and should also provide space for installation of power conduits. The horizontal chases should have connection to the vertical chases that will occur at each of the perimeter columns. The basement should contain multiple electrical rooms located along the perimeter so that each of the vertical chases is located within 50 feet of an electrical room. The basement electrical rooms should each contain branch circuit lighting and power panels to serve the floors above.

8. Install electrical equipment only in electrical rooms: Electrical rooms provided as above along with the chases will provide adequate access to branch circuits. Additional panels should not be installed at any location outside of an electrical room.

9. Conceal horizontal raceways within architectural finishes: The horizontal and vertical chased as mentioned above will provide access for wiring to wall mounted devices. Wiring top ceiling mounted devices such as light fixtures will need to be concealed in coves and hollow spaces as much as possible. Where it is necessary to run conduits horizontally across the ceiling the concrete will need to be channeled so that conduits can be concealed. As much as possible the existing conduits and outlet boxes that are embedded in concrete should be removed.

10. Install accessible flooring in Chambers and Office areas to increase the flexibility of the electrical and communication system wiring: Accessible flooring would provide for a convenient method of preparing for future wiring; however, it is inconsistent with the historical finishes and is therefore not recommended.

11. Restore original lighting fixtures using energy efficient lamps: Original fixtures that are available for restoration should be used. It is recommended that the fixtures that have covers over the lamps should be retrofitted with energy efficient, long-life lamps such as self-ballasted compact fluorescent lamps. Due to the increase in lighting levels, and other factors, the building energy consumption will increase beyond past usage. To help reduce the energy costs it is critical that energy efficient lamps are used as much as possible.

12. Restore original lighting fixtures using energy efficient lamps: Original fixtures that are available for restoration should be used. It is recommended that the fixtures that have covers over the lamps should be retrofitted with energy efficient, long-life lamps such as self-ballasted compact fluorescent lamps. Due to the increase in lighting levels, and other factors, the building energy consumption will increase beyond past usage. To help reduce the energy costs it is critical that energy efficient lamps are used as much as possible.

13. In public areas (These areas are identified as Preservation Area I), replace non-authentic light fixtures with new authentic replicas or restored original fixtures where available : Increased lighting levels will be required in most areas of the building. To provide increased lighting levels, light fixtures will need to be added. It is recommended that the fixtures that are used should be authentic replicas or restored originals. This will require the use of custom fixtures in lieu of "off the shelf" fixtures.

14. Restore historic lighting fixtures in the House, Senate and Supreme Court, but maintain visible incandescent lamps: The original fixtures in the rooms have lamps that are exposed. Due to the modern shape of the new high efficiency compact fluorescent lamps, the historic appearance of the fixtures cannot be maintained if new type lamps are used. It is recommended that these fixtures should be restored to their original condition and should not make use of energy efficient lamps.

15. Install new energy efficient lighting above the skylights: The existing lighting above the skylights is inadequate and needs to be replaced to provide higher lighting levels and conserve energy. It is recommended that new lighting should be provided above all skylights.

16. Install historic or replica light fixtures in stairwells and corridors to meet current IES recommendations and egress lighting requirements per code. It is recommended that new lighting with energy efficient lamps should be used to supplement or replace existing or historic lighting positions with new fixtures.

17. Use historic or replica light fixtures with lamps to generate 50 fc of light at task in offices: Historic fixtures are probably inadequate to generate the required illumination. Replica fixtures can be provided with more lamps than historic fixtures; therefore they are able to provide the added illumination. It is recommended that the offices should be illuminated using replica light fixtures with energy efficient compact or biax fluorescent lamps.

18. Replace relay and or dimming control systems in House, Senate, and elsewhere: The relay and dimming control systems are crucial for energy conservation and to interface with the audio/visual systems. It is recommended that the relay control systems should be microprocessor based and should be provided to control all common area and exterior lighting. The control signals for the relays should come from the building management system that will be used to control the heating, ventilation, and air conditioning.

19. It is recommended dimming control systems should be provided in the House and Senate Chambers and in other areas where Audio/Visual systems will be used. Local control should be provided for the dimming systems. The head-end equipment for both the relay and dimming systems should be located in the basement electrical rooms.

20. Replace all exterior light post with light posts that are consistent with the historical period: A light pole and fixture that is consistent with those that would have been used when the building was constructed should be chosen and should be consistent throughout the site and be functional for the required lighting application. There are many manufacturers of period light fixtures that are suitable. It is recommended that these light poles need to be installed on each walkway and circulation feature (steps, ramps, passenger drop-offs, etc.) with a density sufficient to assure a maintained illuminance level of .5 fc. These should use a metal halide source to be consistent with facade lighting. The poles should be no higher than 14 feet, using a cast iron decorative pole and base.

21. The parking lots should be illuminated to a .5 fc maintained minimum illuminance level using IESNA classified " full cutoff" luminaires: It is recommended that the appearance of the parking area light poles should be consistent with other exterior light poles and should use a metal halide source to be compatible with facade lighting.

22. Illuminate the Capitol Building Facade: It is recommended that the Capitol building facade should be illuminated to a level consistent with the current IESNA recommendations, using metal halide sources. Floodlights for the facade should be mounted on poles and should not be building mounted. The floodlights for the dome should be roof or ground mounted. This floodlighting should be done with metal halide sources, to complement the natural color of the granite.